Clinical Approach to Anterior Adhesive Restorations Using Resin Composite Veneers

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Abstract

Scientific progress in adhesive dentistry has led to more conservative techniques, both direct and indirect, to solve esthetic problems in anterior teeth. This article will discuss only indirect techniques, which are clearly superior in complex cases in which it will be difficult to recreate harmonious tooth shape and color. After reviewing the literature and highlighting the properties of this technique, the indications and benefits compared to the direct technique will be assessed. This is followed by a step-by-step description of operative procedures, from treatment planning to relining and polishing of the cemented adhesive restoration. The long-term success of veneers depends mainly on the tooth preparation, which should be confined to enamel, involve proximal contact areas, maintain the cervical enamel margin, and incorporate the incisal edge to increase veneer resistance and enable correct placement. Although no clinical follow-up similar to that of ceramic materials is available, the latest-generation resin composites offer interesting features. They can withstand mechanical stress, have excellent esthetic properties, and, most importantly, can be repaired intraorally without impairing their physico-chemical and mechanical properties.

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In the past few years, patient requests for esthetic treatment of anterior teeth have increased. In these cases, clinicians often prefer the use of complete crowns to restore esthetics.[1]

Remarkable progress in adhesion research has led to the introduction of more reliable adhesive systems and highly filled hybrid resin composites with microparticles, which offer better chemicophysical properties and adequate mechanical properties.[2]

Today, this evolution is clinically represented by the choice of direct and indirect techniques. Direct techniques are one-session procedures performed chairside by directly applying resin composite to the dental surface. They are used for simple restorations using an anatomic layering procedure, which aids the clinician in correctly defining the color and shape of the tooth, using the residual dental structure as reference.[3]

Indirect techniques demand at least two sessions and the collaboration of a dental technician,[4] who will manufacture a veneer to be luted to the prepared dental surface. Indirect techniques are preferred in more complex cases, in which restoring harmonious tooth shape and color is highly dependent on variables such as the clinician's skill and the technique and material used. Further, it should be considered whether the patient will be more or less compliant about a prolonged session.[5]

In this article, only indirect techniques are discussed, and the most commonly used materials will be considered: dental porcelain and the more recent resin composites. After reviewing the literature and highlighting the properties of each technique, the indications and benefits compared to the direct technique will be assessed. This is followed by a step-by-step description of operative procedures, from treatment planning to relining and polishing of the cemented adhesive restoration. Finally, two clinical cases are presented to illustrate the concepts discussed.

History

The use of ceramic veneers is not a recent development; in fact, in 1938 Pincus[6] described a technique used during Hollywood filmmaking. A common adhesive for total prostheses was used to retain veneers to the tooth surface. The introduction of adhesive systems and their continuous improvement has significantly helped the evolution and increasing clinical success of these techniques.

The materials of choice for veneers are porcelain and resin composite. Baked dental ceramics are made up of two components: a glass matrix and crystalline inclusions.[7,8] In particular, those used in restorative dentistry are reinforced heterogeneous porcelains that contain a greater percentage of crystalline phase than porcelain fused to metal.[9]

Ceramic has always been the material of choice for indirect anterior restorations because of its effectiveness in reproducing the structure and translucency of the natural tooth. Long-term follow-up evaluations of ceramic veneers show excellent biocompatibility and very good chemical stability.[10,11]

The use of resin composite to build anterior indirect restorations is more recent; only in the last few years has research identified materials that offer good polishability, hardness, and wear resistance.[12,13] Such materials belong to a class of highly filled microparticle hybrid composites and are made up of glass filler (70% to 85% in weight) and particles varying from 0.04 to 3 µm in size.

Indications

Thanks to improved oral hygiene habits and the greater reliability of recent esthetic materials, the indications for anterior indirect adhesive restorations have enlarged to cover most patients.[4] However, many authors argue that adhesive restorations should not be used in patients with parafunctions. Magne et al[14] reported that the success rate of ceramic veneers is reduced to 60% in patients with bruxism. Further, they showed a decreased wear resistance in resin composite restorations and a high incidence of fractures in ceramic restorations for these patients.[15] Universally, the following clinical situations are considered indications for anterior indirect restorations:

- Enamel hypoplasia, waves, stains, grooves, etc
- Enamel abrasions
- Congenital imperfect amelogenesis caused by hormones or tetracyclines
- Chromatic or distrophic alterations caused by fluorosis
- Numerous esthetically unsatisfactory superficial restorations
- Coronal fractures located primarily on the palatal side
- Retention of deciduous teeth with a reabsorbed root
- Lateral incisor agenesia, when the canine has transposed to that position
- Volume anomalies (microdens)
- Diastemas
- Alignment defects
- Metal-ceramic crown repair
- Discoloration caused by pulpal necrosis or inadequate root canal therapy

In the authors' opinion, however, this final item should actually be considered a contraindication, since the result is often affected by dischromic relapses of the treated tooth, which may have a negative effect on esthetics over time.

Choice of technique and material

The advantages offered by indirect techniques compared to direct techniques are as follows[16]:

- Superior esthetic result
- Adequate abrasion resistance
- Biocompatibility with soft tissues
- Dimensional and chromatic stability over time
- Strong bond between the two adhesive interfaces (luting agent/etched enamel and luting agent/etched porcelain or postpolymerized resin composite)

Obviously, these advantages are a result of both the intrinsic properties of the material (ceramics) and the superior quality obtained with extraoral work (resin composites). The disadvantages compared to direct techniques are now being reconsidered, as resin composites can actually give excellent results in anterior indirect restorations when used as an alternative to porcelain.

Several useful parameters for selecting the material to be used will now be presented.

Wear resistance

It has been shown that filler hardness and dimension influence resin composite wear when opposed by a natural tooth. The filler hardness should be equal or lower than that of hydroxiapatite.[17]

It has also been demonstrated that when resin composites are subject to a final curing phase by means of both light and heat inside a special oven, they show a remarkable increase in mechanical properties (wear resistance, microhardness, etc) and physical properties (solubility, thermal expansion coefficient, elasticity module, brittleness) compared to resin composites cured with light alone.[18–22] Further, microinfiltration, as measured with dye penetration, decreases dramatically.[22]

These procedures may affect resin composite brightness, so the postpolymerization temperature should be controlled. In 1991, Rueggeberg et al[23] suggested that a final cycle at 100°C for 5 minutes is appropriate. Although ceramics show greater wear resistance than resin composites, they also cause greater wear on the enamel of the antagonist teeth.

Elasticity module and brittleness

According to many clinicians, fractures are more likely in adhesive restorations made with ceramic than with resin composite, because ceramics are stiffer and transmit higher functional stresses to the adhesive interface.[24,25]

To reduce this risk, the following parameters should be considered:

- Relationship between resin composite cement and porcelain thickness
- Position of the margins and preparation shape
- Type of ceramic

Resin composites are more elastic and less affected by microfractures; thus, their use is particularly recommended in patients with parafunctions.

Laboratory procedures and cost

Resin composite veneers require easier laboratory procedures than ceramic veneers, even though veneers built with the refractory cast technique take less time than those fabricated with other methods. Generally, indirect restorations require a greater amount of time and result in more technical difficulties, which explains the higher overall cost of ceramic restorations.[26,27]

Repair potential

If necessary as a result of secondary caries, margin subsiding, or other complications,[28] resin composite veneers are easily repairable intraorally. Marginal inaccuracies during luting can be corrected by curing a small amount of material in place; however, this procedure may jeopardize the performance of the definitive restoration.[29]

The intraoral repair of ceramic veneers is also possible, and the clinical success depends on many factors. The type of ceramic used affects the choice of adhesive material and clinical repair procedure. Glass-based ceramics can be etched with hydrofluoric acid for 2 minutes, followed by application of silane and bonding resin.[30,31]

Another method for bonding resin to porcelain is the CoJet System (3M ESPE), which uses silica acid–modified aluminum oxide particles to sandblast the surface to be bonded. The sand bonds tribochemically (ie, creates a chemical bond using mechanical energy) to the substrate. The surface should then be silanized and bonding resin should be applied. The CoJet system can be applied to aluminum oxide ceramics and zirconium oxide ceramics.[30,32,33]

It can be difficult to select the proper procedure for a long-lasting repair and optimal esthetic result when resin composites are used to seal and repair ceramic veneers, especially for small or medium defects. Large defects or fractures at the incisal margin of ceramic veneers can be repaired, when possible, by adhesively luting a lab-made partial veneer to the fractured veneer.[34]

Polishability

Surface finishing and final polishing are simpler for resin composite restorations than ceramic restorations.[26] It has been suggested that an aggressive finishing of ceramic veneers may remove the surface glaze, thus increasing plaque retention and gingival inflammation.[35] Other authors assert that in these cases an accurate intraoral polishing (specific rubber cups, diamond paste, etc) can restore the surface to its initial condition.[36–38]

Treatment planning

Diagnostic waxup and color registration

The esthetic result of an anterior restoration depends on the shape and color, which are the key parameters of dental esthetics.[3,5,39] For this purpose, diagnostic waxups should be used to evaluate the shape of the final restoration. Prior to tooth preparation, the clinician will plan the final shape of the veneer, type of preparation, and position of the finishing margins. Using a color scale and a 5,000-K lighting system—which should eliminate every source of reflected light and make it easier to discern the various shades of gray—it will be possible to detect all five dimensions of tooth color. As reported by Vanini et al,[3,39] the traditional way to detect tooth color (hue, chrome, value) can be redefined to include five parameters: basic chromaticity, value, intensives, opalescents, and characterizations.

Tooth preparation

The guidelines regarding tooth preparation for a veneer have changed drastically in the last few years. Initially, no preparation was recommended.[40–42] As a result, there was a remarkable increase in tooth thickness and, consequently, proximal and gingival overcontour. Shani et al[43] reported a 90% failure rate for restorations of unprepared teeth.

Today, most authors[16,40,44–47] agree on the importance of a conservative tooth preparation, which offers the following advantages:

- More effective adhesive bond between tooth surface and resin composite cement
- More stable veneer fitting due to precise reference marks
- Reduced possibility of proximal or horizontal overcontouring (with consequent emergence profile alteration)
- Preserved marginal tissue health
- Mild preparation for dischromic teeth
- Overpreparation for morphologic modifications: conoids, diastemas with black triangles (accentuate proximal and mild buccal preparation), and changes to incisor length or prominence (up to 2 mm can be added without inducing stresses)
- More extensive preparation for fractured elements or teeth with acquired morphologic modifications

Enamel reduction

Ideally, the preparation should be confined to enamel,[1,16,48] though Pippin et al[1] confirmed the need to remove the aprismatic enamel isles located mainly in cervical areas. These zones should be analogous to those identified by Gasperic[49] in third molars at a distance between 103 to 756 μm from the cementoenamel junction, and by other authors in anterior teeth at a distance of 0.4 mm from the cementoenamel junction. This is the same area where many clinicians commonly position the finishing line, which is why it is often difficult to obtain a solid bond in this area.[50–52]

According to Caleffi and Berardi,[16] enamel removal should not exceed 0.3 to 0.6 mm, depending on tooth dimension, shape, and pathosis. According to Ferrari et al,[53] the enamel thickness and extension in the cervical area of anterior teeth do not allow a 0.5-mm reduction without dentin exposure. Chalifoux et al[54] showed that enamel removal should not be less than 0.5 mm or greater than 2 mm to avoid decreasing the resistance of ceramic veneers.

Magne et al[55] listed the types of preparation based on the various indications:

Concerning resin composite veneers, Vanini et al[5] emphasized this material's ability to limit the entity of reduction due to the low elasticity module and resulting high capacity to absorb functional stresses. In fact, it is not mandatory to have a minimum thickness of 0.5 mm for resin composite; Perdigao and Lopes[56] suggested a 0.2- to 0.4-mm reduction at the cervical third, a 0.3- to 0.6-mm reduction at the middle third, and a 1.5-mm reduction at the incisal third.

Regarding interproximal surfaces, these same authors argue that the preparation must extend to the contact area without involving it; conversely, Christensen[57] and Caleffi and Berardi[16] suggest including half the contact area in the preparation.

A study by Magne and Douglas,[58] in agreement with Douglas,[59] reported that interproximal enamel reduction does not decrease tooth resistance, while buccal reduction does. The buccal surface of the tooth-veneer complex seems to be more subject to compressive stresses, even though the use of porcelain instead of enamel seems to recover the mechanical properties of the restoration.

It is generally agreed that the position of the cervical margin is a key factor in soft tissue reaction. Pippin et al[1] underlined that the presence of a cervical enamel edge, polishing of restoration margins, and good oral hygiene are key factors to guarantee the periodontal health of restored teeth.

Preparation type

Identifying which type of tooth preparation is least likely to lead to veneer fracture is still controversial.[60] This is especially true for ceramic veneers, which theoretically should be exposed to minimal occlusal load.[41] Toh et al[61] suggested that ceramic veneers should be used only to solve esthetic (and not functional) problems, while Friedman[62] reported that ceramic veneers can restore the anterior guide if there is an appropriate incisal length. In a 15-year follow-up study, fracture, detachment, and microleakage were the most common causes for ceramic veneer failure.[63] Fracture alone represented 67% of the failures. According to this study, the fractures were primarily cohesive and located at the incisal margin, where stresses are higher.

Several types of preparation have been described in the literature. Hui et al[64] and later Clyde and Gilmour[65] described three different designs: *(1)* a "window" or "frame" preparation, where a 1-mm incisal margin is preserved; *(2)* a preparation with a 0.5- to 1-mm incisal bevel; and *(3)* and a preparation with lingual extension.

To increase veneer translucency, Weinberg[66] suggested a 1-mm incisal reduction with rounded angles and edges, while Sheet and Taniguchi[67] described a preparation with a pronounced palatal chamfer and rounded margin for adequate ceramic thickness. Castelnuovo et al[60] advised a preparation incorporating the incisal margin to increase veneer resistance and allow correct insertion. It should be noted that most studies aiming to determine which preparation affords good resistance to ceramic fracture analyze samples using loading systems that are directed from the incisal margin and parallel to the long axis of the tooth; however, functional and parafunctional loads (the latter having 6 times the intensity)[68] acting on the palatal surface of maxillary anterior teeth are directed horizontally.[69]

Porcelain is exposed to fracture when subjected to tensile forces. The maxillary central incisors are mostly affected by this kind of stress, because the compressive forces applied on maxillary incisal margins by mandibular teeth are less than in other teeth.[63] According to the manufacturer, the maximum tensile resistance of feldspar ceramic is 25 MPa (Avantè, Jeneric/Pentron).[49]

Some authors[64,70] report that a frame preparation (ie, with no incisal reduction) seems to be one of the most resistant. Greater fracture values were found in other types of preparation, especially when a palatal chamfer was present. Additionally, no significant differences were observed when increasing the height of ceramics unsustained by dental tissues from 1 to 4 mm.[64] Therefore, the amount of unsustained ceramic is not a critical factor for fractures. Conversely, the palatal chamfer, which is common to both preparation types, appears to be the true weak point. Fractures at the chamfer level extending to the buccal side of the veneer were observed. Thus, it may be preferable to eliminate the palatal chamfer and reduce at least 2 mm at the incisal level, while leaving a butt-joint palatal margin.

An experimental study by Magne et al,[14] carried out by thermocycling the restoration, reported that by increasing the porcelain/resin composite cement ratio it is possible to prevent porcelain fractures. These authors further suggested that the ceramic thickness should be at least 3 times that of the cement. Another study[71] demonstrated the need for a good ceramic thickness and minimum resin composite thickness to reduce thermal contraction and polymerization stresses. Thus, preparation becomes a critical factor in long-term veneer predictability. The same study showed that by providing an adequate resin composite/ceramic ratio, only a butt-joint configuration reduced the risk of ceramic fracture after veneer insertion, as caused by resin composite contraction and thermal changes in the oral cavity. Further, the butt-joint configuration with no palatal extension allows enamel preservation at the restoration margin, which is essential to obtain an effective bond between the veneer and dental surface. The authors concluded that frame preparations with a butt-joint margin and a 2-mm incisal reduction are the most reliable because they guarantee adequate mechanical resistance to the restoration and allow better characterization of the incisal third. Moreover, compared to the palatal chamfer configuration, the butt-joint with no palatal extension is simpler for the clinician, has a better definition when reproduced with a cast, and is more easily read by the dental technician.

Further, a flat surface allows better veneer support and, as opposed to the palatal chamfer and extension configuration, has only one insertion axis. This considerably reduces the risk of fracture in the unsustained ceramic portion.[60]

Regarding the configuration of the cervical third of the preparation, a recent study by Troedson and Derand[48] examined the stress distribution in ceramic veneers made with three different cervical designs: *(1)* a "feather-edge" configuration (modified razor-edge configuration), *(2)* chamfer configuration, and *(3)* shoulder configuration. The results showed that in the presence of moderate stress, the cervical margin design does not influence veneer success. Further, when occlusal loads have various directions reflecting the forces applied on the tooth during mastication, a shoulder configuration is preferable. This study also demonstrated that veneer adhesion is the most important factor to reduce compression and traction forces.

The importance of pre-restoration (buildup) in cases where the tooth is very compromised must be discussed. Magne and Douglas[58] evaluated the stress distribution in teeth with coronal fractures. These teeth were divided into two groups: *(1)* teeth restored with ceramic veneers after a resin composite buildup, and *(2)* teeth restored with ceramic veneers only. The results showed that pre-restoring compromised teeth is a valuable method for guaranteeing better flexibility. A separate study[72] showed that fracture resistance of porcelain is influenced by the elasticity module of the material used for the pre-restoration.

Such procedures also provide an adequate geometry to the preparation and guarantee the restoration material will have constant thickness in every portion, which is an essential requirement for obtaining a thin layer of resin composite cement and greater control of material contraction.[73]

Operative phases

The operative phases and preparation types are identical for ceramic or resin composite veneers. The preparation procedures and necessary tools that, according to evidence-based literature, are able to guarantee a long-term success will now be briefly examined. The use of a silicone template based on a diagnostic waxup is advised during preparation to control tooth reduction. The preparation procedures will now be summarized.

Frame preparation

For the cervical third preparation, a guide-groove should be executed along all cervical contours by means of a round bur. It is very important to preserve a sufficient enamel rim above the cementoenamel junction.

For the mesial, distal, and incisal preparations, the contact points should not be entirely involved, in order to avoid creating undercuts that will prevent proper veneer insertion. A sufficient enamel rim should be preserved at the incisal level.

For the buccal preparation, a longitudinal guide-groove should be executed to gain better control over reduction depth. These grooves should be connected by means of a chamfer bur, respecting the different reduction angles of the whole buccal side.

For preparation finishing at cervical and buccal level, fine-grit burs (red and yellow rings) or medium-abrasive rubber burs should be used.

Incisal reduction and butt-joint with no palatal extension

The first phases are identical to the frame preparation. A 2-mm incisal reduction should follow, providing clean incisal and palatal margins.

Preparation with palatal extension

After carrying out the first two phases of the frame preparation and performing the incisal reduction, two interproximal (mesial and distal) steps should be taken, which should join at the palatal side. The palatal margin, as explained later, may be located at the incisal third (chamfer) or inside the palatal cavity (shoulder), depending on the veneer extension. The chosen palatal finishing line configuration should be a consequence of the bur design itself and be clearly visible in cross-sectional images.

Provisional restoration

Since most of the preparation is contained to enamel, patients seldom complain about intolerable postpreparation sensitivity. Most authors prefer to avoid the application of provisional restorations for several reasons. First, any provisional restoration represents a chemicophysical-irritating factor that may cause tissue inflammation.[27] Furthermore, provisional restorations are unstable and unesthetic. In addition, according to several authors,[16,74–77] the use of temporary cements or adhesive resins would compromise the effectiveness of adhesive procedures; however, Tjan and Nementz[78] argued that the total etch technique can remove any residue left on the tooth surface.

With no provisional restorations, oral hygiene procedures will be easier for the patient, thus guaranteeing ideal health of the periodontal tissues with a remarkable improvement of the tooth-periodontium complex once the restoration is luted. In this case, it is extremely important that the restoration be completed within a maximum time frame of 3 to 5 days.

If significant tooth sensitivity develops, the application of fluoride-based gels using an individual tray can be used. Paul and Sharer[79] demonstrated that applying a bonding resin after cavity preparation (dual bonding technique) reduces postoperative sensitivity, which is generally considered a symptom of bacterial contamination and hydrodynamic phenomena.[80,81]

If necessary, such as with very large preparations and/or after patient request, it is possible to execute chairside direct provisional self-curing acrylic resin veneers, using a silicone template based on an esthetic diagnostic waxup. These provisional veneers should be temporarily fixed by positioning a small amount of resin composite without any adhesive procedures.[82–85]

Veneer clinical check

A veneer should be tried on to evaluate the marginal adaptation, stability, shape, and color. No corrections by adding material can be performed on porcelain veneers, and all occlusal checks should be performed after luting to avoid accidental fracture.[86]

If resin composite veneers are used, it is possible to modify them before luting by roughening their surface, applying bonding resin, and adding a small amount of material.[87] To restore the mechanical properties of the restoration, further postpolymerization is necessary.

Luting procedures

Luting procedures are a crucial step in the overall treatment. Indirect adhesive restorations are retained by means of micromechanical adhesion between the resin composite cement and both the tooth surface and restorative material. Marginal quality and precision of luted restorations is strictly dependant on the following factors.

Adhesive potential of substrate

As mentioned previously, the best internal adaptation and marginal seal are obtained when the preparation is entirely surrounded by enamel.[4] It has been demonstrated that exceedingly aggressive etching, excessive dryness of the etched surface, or high compression of the collagen fiber network during impression taking or luting procedures[23,80] may cause denaturation and/or collapse of the collagen fibers. A hybrid layer only partially impregnated with resin would allow enzyme and ion infiltration. This phenomenon, called *nanoleakage*, can cause adhesive bond failure and restoration detachment.

The dual bonding technique (ie, the application of a bonding resin at the end of the preparation) can stabilize adhesion because it does not allow contamination caused by impression materials and temporary cement, but still preserves the adhesive interface from the abovementioned procedures.[77]

Adhesive potential of ceramic

Adhesion between resin composite and porcelain is based on a combination of micromechanical and physical bonds, which has been shown in vitro to be more effective than either type of bond by itself.[74,88,89] By etching the veneer surface with hydrofluoric acid and then applying silane, the bond between resin composite cement and porcelain is stronger than that between cement and etched enamel.[47,89–91] Scanning electronic microscope (SEM) imaging of etched ceramics has shown a structure filled with micropores,[47,89,92] which increases the available surface for adhesion and allows the micromechanical bond of resin composites.

Many authors report that the adhesive bond between the cement and treated surface depends on the type of silane used.[39,93–95] Treating the silanized surface with heat (about 100°C) has been proven to create an adhesive bond that is twice as strong.[96] Pretreated ceramic bonds are negatively influenced by external factors such as water absorption, changes in temperature, and contamination by latex gloves, saliva, and the fit checker.[97] In these cases, retreating the contaminated surface with 37% phosphoric acid followed by silanization may restore the original adhesive potential. However, Sheth et al[97] argued that the original bond strength cannot be restored after contamination.

Stacey[47] observed that 43% of ceramic veneer adhesive failures were found at the enamel-cement-composite interface. Particularly, the micromechanical bond was lower at the cervical level. Arakawa et al[98] confirmed this result by observing minimal size interdigitations in this area. Many factors, such as etching time, etching agent concentration, veneer execution type,[89,90] and ceramic type, influence morphology and thus the retentive capacity of etched ceramics.[96,99] It has been reported that increased etching time increases the initial microfractures of ceramic surfaces, thus reducing the flexural resistance of the veneer.[43,100] To obtain a significant increase in surface energy, etching with 7.5% to 10% hydrofluoric acid for 2 to 10 minutes is necessary.[48]

Ultrasonic devices are useful to remove acid residues on ceramic surfaces.[101] An SEM analysis of treated feldspar ceramics surfaces showed more retentive surface in terms of penetrability.[94,102]

Adhesive potential of resin composite

For inlays, roughening the internal surface of resin composite veneers is effective to create microretentions and obtain a bond between the resin layered on the restoration and the free radicals. This should preferably be performed via sandblasting or a coarse-grit diamond bur.[103–105] Once the veneer has been roughened, it should be cleaned with alcohol and silanized with thermal treatment.

Resin composite cement

Cement type

The use of light-curing cement is preferred to a dual-curing cement[101] because it allows a longer working time for luting procedures. It also makes it easier to remove any excess before light activation. Finally, the chemical stability of light-curing cements helps maintain esthetics over time. It should be noted, however, that ceramic absorbs 40% to 50% of the light emitted; therefore, its thickness will be the main factor influencing the amount of light absorbed.[92,106] Color and opacity, on the other hand, have only a minimal influence.[92,107,108]

Linden[107] demonstrated that ceramic opacity becomes an important factor when ceramic thickness is greater than 0.7 mm. In these cases, O'Keefe et al[92] suggested doubling the veneer exposition time. Conversely, Linden et al[107] argued that the only solution is to use dual-curing cement, because thick ceramic seems to prevent the cement from reaching sufficient hardness. It is also better to use a highly filled resin composite cement (at least 65% in volume) with a medium-high viscosity, because of its low thermal expansion coefficient and lower polymerization shrinkage.[44,78,109] This is essential for ceramic veneer luting, because it allows the creation of an elasticity module gradient through the dental surface, resin composite cement, and porcelain surface.[110] The viscosity of this kind of cement is very high, so resin composite preheating is required to decrease the viscosity when it is applied as a thin layer on the veneer surface. Next, the veneer should be positioned gently on the tooth preparation.

Cement thickness

A meticulous application of the operative protocol requires a highly precise impression of the preparation. Once the stone cast is made, die spacer should be applied onto the cast to provide space for the luting agent. The resin composite cement layer should be as thin as possible to allow correct veneer placement and marginal precision; also, a thin cement layer will have a minimal contraction[73] and leave a smaller gap between the tooth and restoration.[111]

Die spacer application provides a layer of about 25 μm or more depending on the number of coats.[112] Kramer et al[113] reported that recent luting cements have excellent flow characteristics with mean film thicknesses ranging from 8 to 21 μm. The flowability of viscous luting composites or conventional restorative composites can be increased by using an ultrasonic tip and/or by preheating the resin composite itself.

A finite element model study by Magne et al,[71] which aimed to highlight the effects of thermal changes and resin composite cement shrinkage on microfracture formation in ceramic veneers, reported some interesting results. It was demonstrated that the amount of stress generated by resin composite shrinkage on the surface and at the restoration interface is strictly due to the ratio of porcelain to cement thickness. As mentioned before, the ceramic thickness should be at least 3 times that of cement; if this ratio decreases, a preparation configuration with an incisal reduction and palatal butt-joint is needed to reduce the palatal fracture risk caused by restoration insertion or resin composite shrinkage and thermal changes in the oral environment. This problem is relevant mostly at the restoration margins, where ceramic thickness is remarkably reduced compared to that of resin composite cement.

As has already been discussed, fracture risk is significantly less likely in resin composite veneers. Resin composite is not as fragile as ceramic, and may absorb functional stress through the adhesive interface to a greater extent.[25] Thus, it is not imperative to obtain a material thickness 3 times greater than adhesive cement, as for ceramic restorations.

Application and polymerization

Once the provisional restoration has been removed using hand instruments, and after field isolation using rubber dam and floss binding, the teeth should be cleaned with pumice and ultrafine brushes. During this phase, some authors prefer the use of a bicarbonate spray to easily remove residual pigmentation.[74,76,77,79] The tooth surface and internal side of the restoration surface should be treated to prepare them for adhesion,[2] and cement should then be applied onto both surfaces with a spatula and dragged to the margins with a small brush.[114] Since there may be a slight loss in value after restoration luting, a white mass should be used during this phase. For resin composite veneer luting, it is recommended to use the same material from which the veneer itself is made.

The veneer should be positioned and any excess cement removed using brushes, probes, and floss. The restoration should then be light cured (at least 1 minute per side) to guarantee an optimal degree of conversion of the material.[115–117] It is well known that oxygen hinders complete monomer conversion.[118,119] so a glycerine-based gel should be applied to the interface during final light curing to avoid the formation of an inhibited layer (air block).

Finishing and polishing

A number of materials are now available on the market. These procedures are performed to correct any superficial defects, smooth irregular surfaces, and obtain perfect marginal continuity between the restoration and tooth surface.[4]

It has been shown that polishing ceramic veneers may remove the superficial glaze, which could be a cause of plaque retention and gingival irritation.[120] According to Magne et al,[37] ceramic should be polished intraorally to avoid this problem and obtain a surface with analogous properties to one finished in the laboratory.

The best finishing of a ceramic veneer is that obtained on a laboratory bench; therefore, if possible, the authors absolutely advise not to touch ceramic veneers with abrasive tools during luting procedures. Regarding resin composite veneer finishing, the operative sequence comprises the following: fine-grit diamond burs, silicone points, brushes impregnated with diamond paste, and aluminum oxide. These will guarantee a brilliant restoration.[2,110] Sealing the restoration margin using a flowable resin composite is an effective way to fill eventual marginal microdefects.

Restoration maintenance

As with esthetic inlays/onlays, a recall visit should be performed every year to check the functional stability, closure margins, and health of the surrounding gingival tissues, as well as to evaluate any esthetic modifications required. After veneer surface polishing with aluminum oxide, margin etching and sealing with flowable resin composite should be performed.

Evaluation parameters

Esthetic result

Long-term studies of the esthetic behavior of resin composite veneers are very promising, thanks to the excellent esthetic properties of recent materials. Several studies[28,121,122] have confirmed the color stability of porcelain veneers over time.

Indirect resin composite restorations are useful for masking severe discoloration or achieving a certain esthetic effect. Because the veneer should be luted with the same material used for its fabrication, the clinician has a greater choice of color shades, making it easier to produce slight modifications of the esthetics.

Periodontal response

Only a few long-term studies confirming the good integration of resin composite veneers with the surrounding periodontal tissues have been published. Indirect techniques allow a level of marginal precision that is absolutely comparable to that of ceramics. In addition, the latest-generation resin composites show enhanced superficial polishing and smoothness characteristics. Thus, it is possible to achieve promising results in terms of periodontal integrity.

A number of long-term studies demonstrated the biocompatibility and low plaque retention of ceramic.[35,123–130] Peumans et al[120] reported mild plaque presence at the marginal level 5 years after luting as a result of glaze removal during finishing.

Margin positioning plays a fundamental role in periodontal tissues response, which suffers when the margin is placed far from the gingival contour.[129] All authors agree that in the presence of good oral hygiene, margins that are precise, well-finished, and placed above the gingival level will guarantee good periodontal health.[35,65,129–132]

To demonstrate these concepts, two clinical cases demonstrating the most prevalent indications for ceramic or resin composite veneers will now be presented.

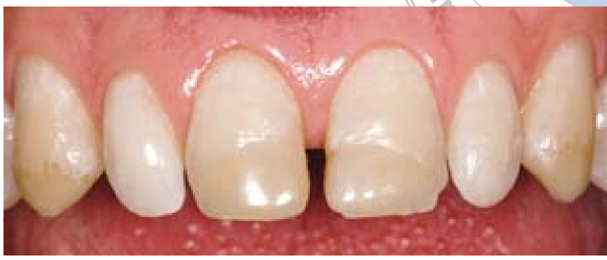
Clinical Case Reports

Case 1

This case involved remaking incongruous Class 4 restorations on the maxillary central incisors, restoring shape/color defects on the maxillary lateral incisors and canines using ceramic veneers, and correcting enamel hypoplasia on the mandibular incisors (Figs 1 and 2).

A clinical situation such as this is one of the clearest indications for esthetic veneer treatment, especially for patients who have repeatedly sought a perfect esthetic intervention and instead found their smile ruined by unsatisfactory restorations. Today, it is possible to achieve excellence even with direct techniques; however, in the authors' opinion, in cases like this it is simpler and more predictable to use indirect techniques.

Figures 3 and 4 show the preparations of the maxillary and mandibular teeth. The veneers received from the dental technician are shown in Figs 5 and 6. After replicating the cast, the ceramic (Avanté, Jeneric/Pentron) was layered and baked in the oven. The veneers were tried in, adhesively luted (with the use of rubber dam), and polished. The cement used was Calibra (Dentsply). The final result is shown in Figs 7 to 9.

Figs 1 and 2 Initial situation.


Figs 3 and 4 Preparations of the maxillary and mandibular teeth.


Figs 5 and 6 Veneers for the maxillary and mandibular teeth.


Figs 7 and 8 Final result.

Fig 9 Final result.

Case 2

This case involved replacing two direct restorations on the maxillary right lateral incisor and left central incisor, and correcting enamel anomalies on the right central incisor and left lateral incisor (Fig 10). Resin composite veneers (Enamel Plus HFO, Micerium) were used and luted with the same resin composite material. The dentin bonding agent used was EnaBond (Micerium).

In this case, a conservative preparation confined to the enamel layer was used (Fig 11). The manufactured resin composite veneers are shown in Fig 12. The laboratory procedures for this material are much simpler than for ceramic veneers; the material is layered on the cast and each increment is light cured. A final postpolymerization treatment inside a light-heat oven is necessary, but no baking is required. Use of rubber dam not only provides operating field isolation, but also allows the clinician to carry out each operative step with absolute calm and concentration (Fig 13). The final result is shown in Fig 14.

Conclusions

The success of anterior indirect restorations depends on proper treatment planning and application of the operative protocol. Medium- and long-term follow-up studies[35,65,129–134] of ceramic veneers have shown satisfactory results regarding esthetic result and periodontal response. Respecting every step of the treatment protocol will reduce the percentage of failure in cases with a high risk of veneer fracture. Despite the small number of studies in the literature, it should be underlined that resin composite veneers have undeniable advantages and may represent the future of this technique for the following reasons:

- Luting procedures are less complicated and risky thanks to the resin composite's greater ability to absorb the polymerization stress of the adhesive cement.
- Chairside finishing and polishing maneuvers are simpler and less likely to increase fracture risk, as in ceramic.

Fig 10 Initial situation.

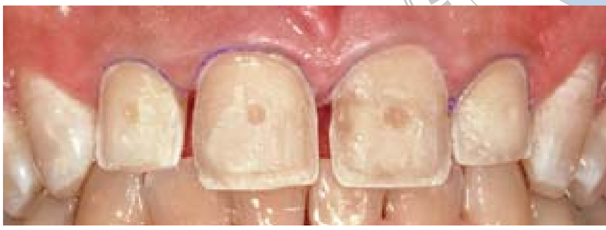


Fig 11 A conservative preparation was carried out.

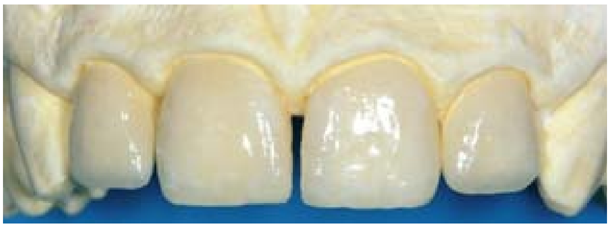


Fig 12 Resin composite veneers.

Fig 13 Rubber dam was used for field isolation.

Fig 14 Final result.

- Resin composite veneers can be modified before luting without compromising either their mechanical properties or adhesive potential.
- Cost is lower due to simpler laboratory procedures, and the range of application is wider than with ceramic.

With these considerations in mind, it is the authors' opinion that in the near future the use of ceramic in anterior indirect adhesive restorations will decrease, while the use of resin composite will increase.

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